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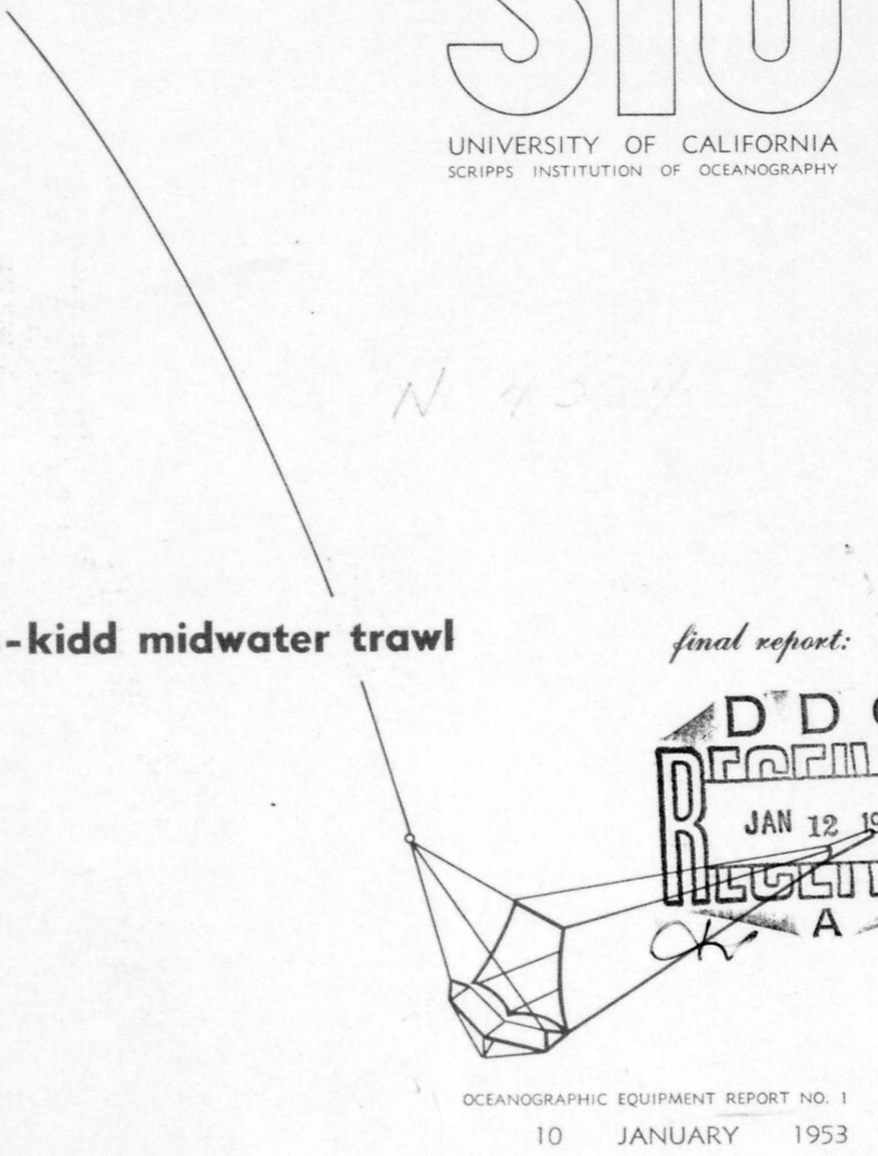
isaacs-kidd midwater trawl

final report:



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abstract

The Isaacs-Kidd Midwater Trawl collects bathypelagic biological specimens larger and more active than those taken by standard plankton nets. The trawl consists essentially of a net of special design attached to a wide, V-shaped, rigid diving vane. The vane keeps the mouth of the net open and exerts a depressing force, maintaining the trawl at depth for extended periods at towing speeds up to five kt. The inlet opening is unobstructed by the towing cable. The new trawl has been successfully tested to a depth of approximately 3700 m. It has already collected several species of bathypelagic fishes not reported from the Pacific before, and species new to scientific literature.

This report describes the tests conducted to evaluate the device, discusses the results, and includes sections on conclusions and recommendations for further work.

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NOTE: This report supersedes the earlier report, A Midwater Trawl by John D. Isaacs and Lewis W. Kidd, SIO Reference 51-51, 15 November 1951, a preliminary report issued while the trawl was still under development.

The work on the Isaacs-Kidd Midwater Trawl has been sponsored jointly by three government agencies. They are the Bureau of Ships (Contract NObsr-43356, NE 120221-6), the Marine Research Committee of the State of California, and the U.S. Navy Office of Naval Research (Project NR-083-005 Contract N6ori - III, T.O. VI).

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introduction

Oceanographers have long felt the need for a collecting device intended specifically to collect bathypelagic biological midwater specimens larger and more active than those taken by standard plankton nets. Marine creatures living in the surface layers and on the bottom have been rather adequately sampled by existing apparatus. but those which live between the surface and the bottom in deep water have to a large extent eluded systematic investigation for lack of an efficient collector.

The Isaacs-Kidd Midwater Trawl, developed at University of California's Scripps Institution of Oceanography, in part answers this need. It has been successfully tested to a depth of approximately 3700 m (1900 fm). Although tests were conducted primarily for the purpose of studying the performance characteristics of the trawl itself, the device collected several species of bathypelagic fishes not previously reported from the Pacific, and species new to scientific literature.

statement of the problem

The problem was to design and perfect a self-depressing, deep running net for collecting bathypelagic specimens. It was decided that the net should be larger than those ordinarily used, should be capable of being towed at a higher velocity and should have good diving and stability characteristics with a minimum of sensitivity to changes in tow velocity. The inlet opening of the net should be unobstructed by the towing cable. The relationship between the horizontal and vertical dimensions of the inlet should remain constant during tow. The lower edge of the net should precede the upper edge while towing, on the assumption that creatures frightened by the trawl would tend to sound.

development

The first experimental model incorporated a flat steel sheet as the depressing vane and used the commercial shrimp fisherman's try-net as a collector. This preliminary investigation indicated that dihedral (in this case an upright V since the depressing surface is supported at each end) is necessary.

The second model, closely resembling the trawl in its present form, proved very successful. Trials were continued in search of improvements.

Previous work with depressors indicates that hydrofoil sections are not desirable for use as the trawl's depressing surface.

description

The Isaacs-Kidd Midwater Trawl (IKMT), illustrated in Figure 1, consists essentially of a cone-like net of special design attached to a wide, V-shaped diving vane, the entire assembly being oriented by a towing bridle. The net terminates in a detachable container (the "cod end can" or an adaptation of the standard meter net) where specimens are retained until the trawl can be retrieved to the surface.

The IKMT is towed by vessels, (as shown in Figure 2,) using steel cable. The trawl depresses itself to a depth related to cable length and towing speed. At depth the trawl collects, filters in, and retains bathypelagic specimens. When the trawl is retrieved, specimens are removed from the cod end container for scientific study.

Two models of the IKMT have been constructed, differing principally in size and material. The 15-foot trawl is essentially a scaled-up version of the 10-foot model. Principal dimensions and materials are tabulated below.

		10-FOOT TRAWL	15-FOOT TRAWL
BRIDLE	material	0.250-inch wire rope	0.380-inch wire rope
	spread (ft.)	10	15
VANE	area (sq. ft.)	21	64
	weight (lb.)	150	400
	material	0.125-inch steel	0.75-inch marine plywood
NET	length (ft)	31	72
	inlet area (sq ft)	80	160
	material	2.5-inch stretch, no. 24 medium lay seine	2.5-inch stretch, no. 36 medium lay seine
LINER	material	0.5-inch stretch bait netting	0.5-inch stretch bait netting
COD END CAN	material	steel	aluminum
	length (in)	13.5	24
	diameter (in)	9.5	16
	no. baffles	none	2

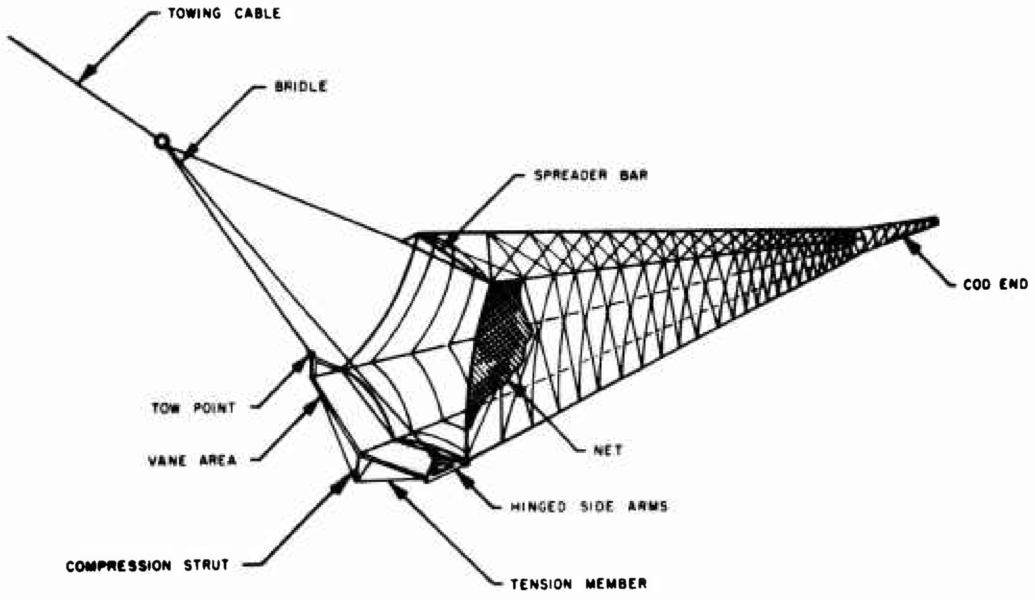


Figure 1. The Isaacs-Kidd Midwater Trawl

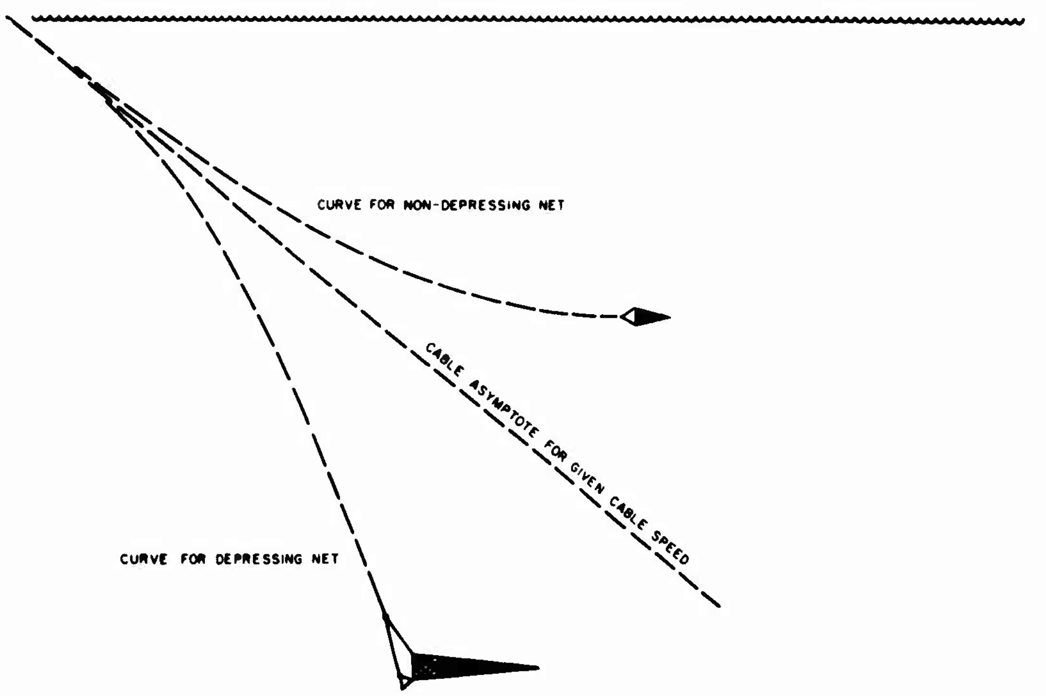


Figure 2 Comparison of Isaacs-Kidd Midwater Trawl and non-depressing net

the bridle

The bridle of the trawl is made of wire rope. Sling links, wire rope sockets, and missing link connectors (all of which present no sharp or irregular projections) are used throughout to prevent fouling and tearing the net in shipboard operations. For connectors that must be opened frequently (for example in dismantling the trawl for stowing) standard screw-pin shackles with pin eyes removed are used. The shackles are wrapped and bound in canvas.

Two legs of the bridle attach to the side arms of the vane. The third goes to the spreader bar (at the top panel of the net) and divides into two parts which attach to each end of the bar. The third leg may be altered in length to position the leading edge of the top panel of the net directly above the vane or at a point trailing that location.

The bridle performs the dual function of orienting the vane and upper leading edge of the net and (as a towing bridle) of connecting the trawl to the towing cable.

the vane

The vane for the 10-foot trawl is constructed from two sheets of 0.125-in. steel plate 24 in. wide and 5 ft 3 in. long. The ends of the sheets are welded together at a 140-degree included angle to give 20 degrees dihedral. The vane for the 15-foot trawl is similar except that plywood is used instead of steel. The leading edge of the vane is reinforced with thick-wall steel tube as a load-carrying member.

While being towed by the lower legs of the bridle and restrained by the haul lines of the net, the vane assumes an attitude which causes the entire trawl to be depressed to a depth related to cable length and towing speed.

the side arms

Hinged at the ends of the vane are side arms fabricated from 1.5 x 0.250-in. steel flatbar welded to form a triangle. In position as when towing, the tow point, formed by one corner of the triangle, is 29 in. above and 6 in. forward of the leading edge of the vane, measured from a line from the leading edge perpendicular to the hinge axis of the side arm.

The vane is attached to the bridle through the side arms. The side arms maintain the tow point in proper relation to the vane, in a fore and aft direction. To permit the bridle to exert a straight pull at the ends of the vane (i.e., with absence of load-induced bending moment upon the vane resulting from misalignment) the side arms are hinged, permitting them to swing about an axis parallel to the logitudinal axis of the vane. With the side arms so hinged the vane can fold, if the vane tension member fails, without disturbing the tow point location in a fore and aft direction.

the tension member

A tension member of galvanized, improved plow-steel wire rope spans the underside of the vane from end to end and is separated from it at the center by a compression strut. The vane is made rigid, spanwise, by the tension member. A turnbuckle at one end of the tension member is used to take up slack. It is adjusted so that the tubular leading edge of the vane will assume some of the load in bending before the tension member becomes entirely taut. The tension member is the weakest link in the system of towing cable, bridle, and vane and is intended to part under excessive load, permitting the vane to fold.

the compression strut

The compression strut is a V-shaped member located at the center of the underside of the vane. The compression strut completes the vane and tension member structure. The contact point between the tension member and the compression strut is a segment of a wire rope thimble attached to the compression strut. The thimble segment prevents chafing resulting from tension member vibration.

the spreader bar

The spreader bar at the leading edge of the top panel of the net is constructed from black iron pipe. It performs the function of aiding the vane in keeping the inlet of the net open while towing.

the net

Nets for the 10-foot trawl are 31 ft long (182 mesh). The net is approximately conical in shape, tapering for three-quarters of its length toward the after end where it assumes an approximately tubular shape. From that point aft (known as the "cod end" of the net) the taper is much more gradual, reducing in diameter from 25 in. to 16 in. in 8.5 ft.

Made of 2.5-in. stretch seine, the net is lined with 0.5-in. stretch bait netting from a point 3 ft forward of the cod end back to the terminus of the net. The net is reinforced by five haul lines of 0.5-in. manila rope, the forward ends of which become the attaching points of the net and the after ends of which are spliced to the cod end haul lines. The cod end haul lines are 0.375-in. cotton rope. The cod end is maintained in its approximately tubular shape by steel rings.

Points of attachment of the net are to the center and ends of the vane and tc each end of the spreader bar. Galvanized thimbles are spliced intc all the haul lines, except that to the center of the vane, approximately 1 ft ahead of the leading edge of the net. To make allowance for the attitude the vane assumes during tow, the haul line to the center of the vane is terminated immediately forward of the leading edge of the net. At the cod end all haul lines are terminated by bronze boat snaps which attach to the cod end can or meter net adaptor.

The net liner is sewn to the haul lines at 1.5-in. intervals throughout the length of the liner. It is tacked to the net at random, one tack per 0.5-ft area. The cod end rings are sewn between the liner and the net.

The function of the net is to separate specimens from the water taken in and conduct the creatures along the interior of the net, through the cod end, and into the cod end container, with minimum damage to the specimens and maximum filtering out of water. The reinforcing haul lines incorporated in the net also serve to prevent loss of the cod end container.

the cod end container

The cod end container for the 10-foot trawl is 9.5 in. square and 13.6 in. deep. It is completely open at the forward end. Side corners are rounded. The bottom, or after end, is perforated with forty-one 0.218-in. holes and three hundred and twenty-six 0.125-in. holes, spaced at random. The sides are perforated with ninety-eight 0.187-in. holes in an area extending 2.375 in. from the bottom, or after end, of the container.

The container is inserted in the cod end of the net and held in place with drawstrings.

The container retains the specimens in good condition, preventing their escape by permitting a steady inward flow of water while at the same time preventing the flow of water into the container from causing specimen-destroying turbulence or exhaust-port plugging and extrusion of the specimens.

meter net adaptation

A standard meter net may be used in place of the cod end container by using a canvas adaptor section to match the 1-m diameter of the meter net inlet to the 16-in. diameter of the cod end terminus. The adaptation has proved very successful in preventing damage to specimens.

tests

studies of the trawl as a towed object

The Isaacs-Kidd Midwater Trawl has undergone a number of performance tests, which are described and discussed in the following section and the results of which are graphically presented in the accompanying illustrations.

instrumentation

The instrumentation described below was used in the performance tests:

1) Tensile load on towing cable was recorded using the Dillon dynamometer, as calibrated at the factory.

2) Length of cable overboard was indicated by the meter wheel of the winch.

3) Speed-of-tow data were obtained over the measured nautical mile off the La Jolla range in two-way runs at approximately 250 m depth. All speeds were corrected for current.

4) Depth of trawl direct indications proved to be inconclusive using the only available depth recorder. All depths shown were calculated from cable angles.

5) Cable angles were determined using a protractor machinist's square.

effects of the net

A liner of 0.250-in. mesh net was installed the entire length of one of the 10-foot trawl nets. A short test using 0.375-in. towing cable indicated no appreciable change in performance characteristics. Drag and wire angles for various depths and towing speeds appeared to approximate those for the trawl with liner material in the cod end only.

The most recent work with the fully lined net is that in which the trawl was towed with 0.5-in. cable. At 3 kt the performance characteristics approximated those demonstrated using the 0.375-in. cable. For speeds greater or less than 3 kt there was a measurable difference in angles between the two sizes of cable.

cod end

Tests indicate that it is necessary to have the liner material in the cod end sewn to the haul lines and tacked to the larger netting. Apparently there is considerable vibration in this turbulent area. The added inertia of the haul lines and large mesh provides a damping effect and helps to hold more rigid the funnel through which the specimens must pass to reach the cod end container.

ship maneuverability

Maneuverability of a ship towing the trawl is limited only by the amount of towing cable used. With the trawl directly below the propeller wash a ship was put through a series of maneuvers -- sharp turns, acceleration and deceleration -- during performance tests. The trawl proved to be extremely stable under these conditions and demonstrated no tendency to surface or wander erratically.

When operating with a short length of towing cable (40 to 100 m) it was found that shock load resulting from pitching of the ship adds considerably to tensile load on the towing cable. Care should be exercised in establishing the speed of tow, especially when peak cable loads approach the upper limit of the cable's safe working capacity.

discussion of results

In Figure 3 the towing cable depression angles plotted against towing speeds show the relative diving efficiency of the two trawls with respect to depth of trawl attainable with a given length of cable. For continuous operation a towing speed of not greater than 5 kt is recommended for the 10-foot model. At greater speeds the vane tension member showed signs of yielding. In Figure 4 the curves of cable tensile load vs towing speed indicate that 0.375-in. wire rope is a satisfactory towing cable for the 10-foot trawl. Insufficient data have been gathered to establish the relationship of cable load vs cable length for the 10-foot model. The data that do exist are presented in Figure 5 to give a general idea of the cable loads encountered when the trawl is operated at considerable depth at a speed of 3.1 kt. Under these conditions a cable load of 3,000 lb with 4,500 m cable length may be taken as a definite point.

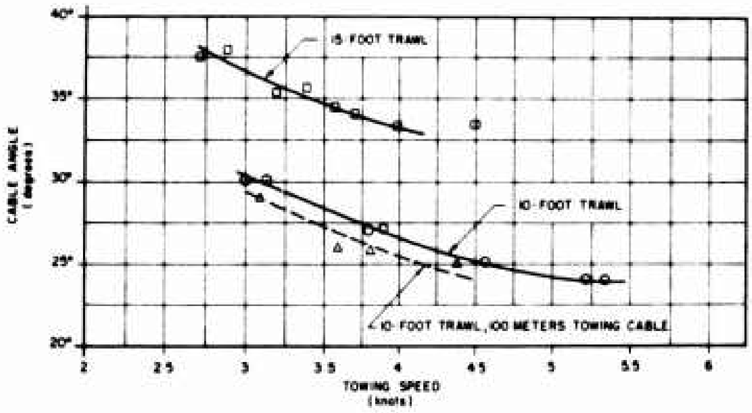


Figure 3. Comparison of towing cable angles, 10- and 15- foot Isaacs-Kidd Midwater Trawl, using 40 meters of 3/8-inch cable

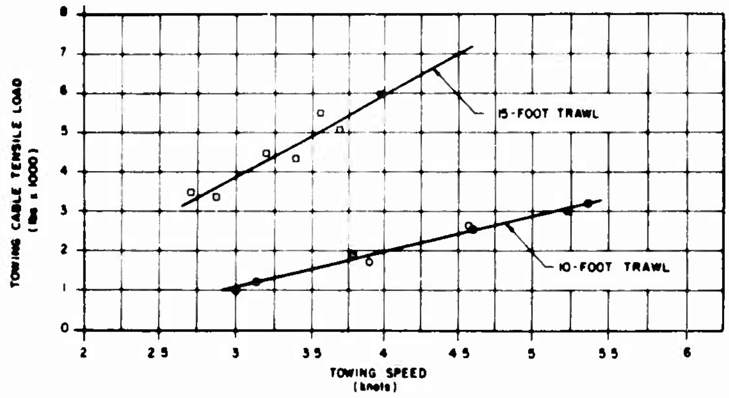


Figure 4. Comparison of towing cable tensile loads, 10- and 15- foot Isaacs-Kidd Midwater Trawl, using 40 meters of 3/8-inch cable

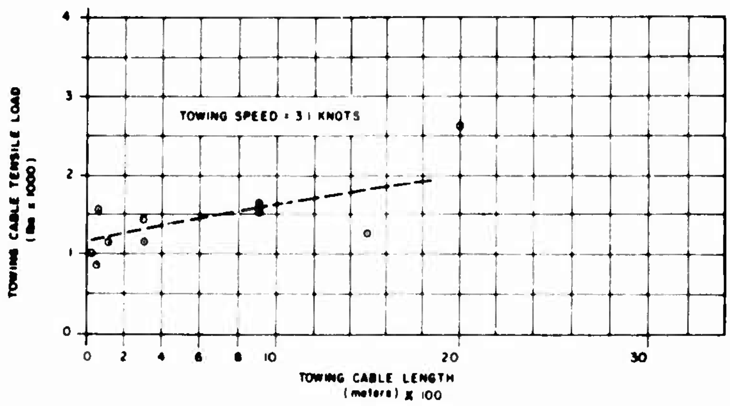


Figure 5. Towing cable tensile load vs cable length, at 3.1 knots towing speed using 3/8-inch cable, Isaacs-Kidd 10-foot Midwater Trawl

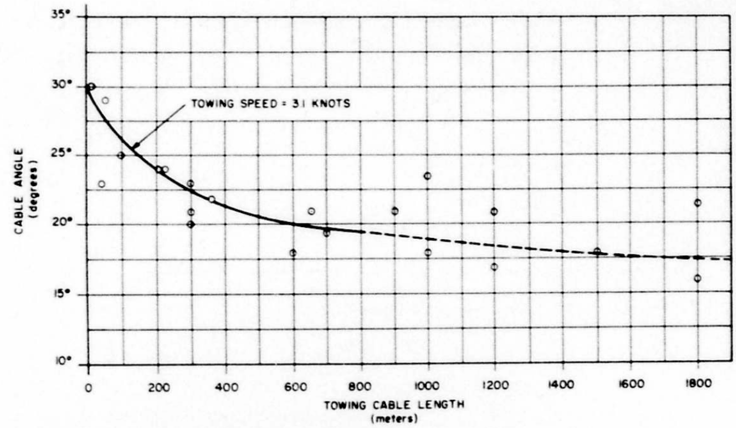


Figure 6. Towing cable angle vs cable length, at 3.1 knots towing speed using 3/8-inch cable, 10-foot Isaacs-Kidd Midwater Trawl.

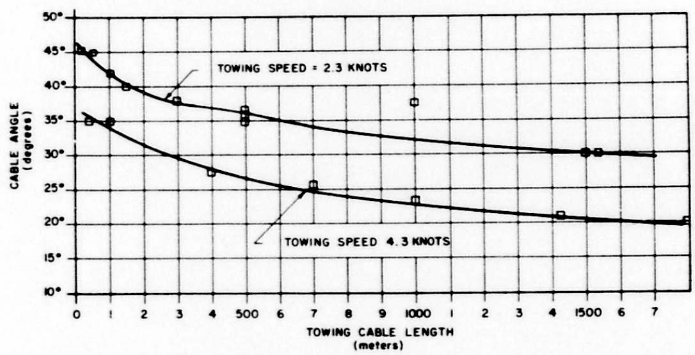


Figure 7. Towing cable angle vs cable length, at 2.3 and 4.3 knots using 3/8-inch cable, 15-foot Isaacs-Kidd Midwater Trawl.

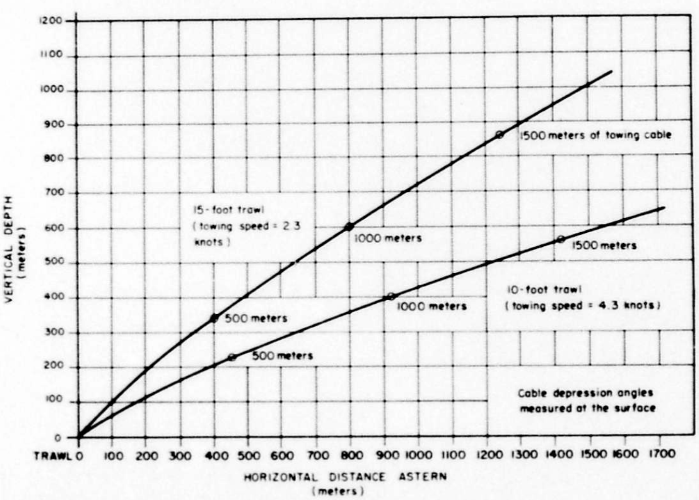


Figure 8. Vertical depth vs horizontal distance astern showing length of 3/8-inch towing cable required, 10- and 15-foot Isaacs-Kidd Midwater Trawl.

In Figures 6 and 7 cable angles vs cable length are presented for each model. Cable angles for the 10-foot trawl have been measured for cable lengths up to and including 5,050 m. Angles for cables more than 1800 m long are not presented, however, because angles for lengths greater than 1800 m appear to be quite variable, depending upon how the tow is initiated.

Two methods of initiating the tow have been used. Plan One, less satisfactory than Plan Two, goes as follows.

1) Launch trawl at bare steerage way.

2) When trawl reaches keel depth stream at speed greater than towing speed. Pay out desired length of cable as rapidly as possible, maintaining only enough tension to prevent kinks from developing in the cable.

3) When the desired cable length has been paid out, slow ship to towing speed.

It has been found that with Plan One the cable will assume a relatively steady angle within five or ten minutes after towing speed has been set. As the tow proceeds, however, the cable angle increases very slowly. In eight or nine hours the cable angle may increase from, for example, 15 degrees initial angle to 20 degrees. The increase indicates that the trawl and cable are slowly approaching an equilibrium condition where the trawl would be fishing at the maximum possible depth for a given speed and cable length.

Plan Two, which is that normally used in making deep hauls, is as follows:

1) Launch Trawl as above.

2) Pay out cable as in Plan One.

3) When the desired cable length has been extended, reduce ship speed to a velocity somewhat lower than the predetermined towing speed.

4) Allow approximately 40 minutes to an hour at slow speed for cable and trawl to settle to a depth equal to or greater than equilibrium towing depth.

5) Increase ship speed to the predetermined towing speed.

Time consumed in making a four-hour deep haul is reduced by Plan Two because less time is spent reaching the desired depth.

Vertical depth vs distance astern, showing cable length required, is presented in Figure 8.

ou^t growth

During performance tests, contact was made with the ocean bottom on several occasions. The depth was known, and contact served to verify calculations of trawl depth from cable angle. Not only was the trawl not damaged but it collected rock specimens while in contact. It was decided to construct a bottom sampling dredge having self-depressing characteristics, patterned after the IKMT.

The Diving Dredge, as the device has since come to be called, has proved to be a great advance over existing bottom sampling devices. A summary report covering development of the dredge is in preparation.

studies of the trawl as a collecting device

No tests have been conducted specifically to determine how effective the IKMT fulfills its function as a collector of bathypelagic specimens. There are few criteria that may be used in judging the effectiveness of such a device. To attempt to set up a test to compare the IKMT with the few types of collectors used in midwater now and in the past presents problems of test control which are rather more than formidable. It is interesting to note, however, that during the tests which were conducted to investigate and evaluate only the physical behavior (performance) of the trawl, a number of specimens were taken in midwater which represent new species, and species previously unreported from the Pacific. Typical specimens are shown in Figures 9 through 11.

In a test which was run to determine whether fast-moving specimens can elude the trawl, a quantity of anchovies were captured at 14 m depth, towing at 5 kt. In a similar near-surface run the 10-foot trawl was towed through a dense area of kelp. The trawl was retrieved completely filled with kelp. There was no damage to the vane or the net.

Since the performance tests were conducted, the IKMT has been placed in service. How well it accomplishes its purpose may be judged from the following facts

1) In the short time the IKMT has been in use specimens have been taken which have eluded hundreds of tows using the conventional meter net.

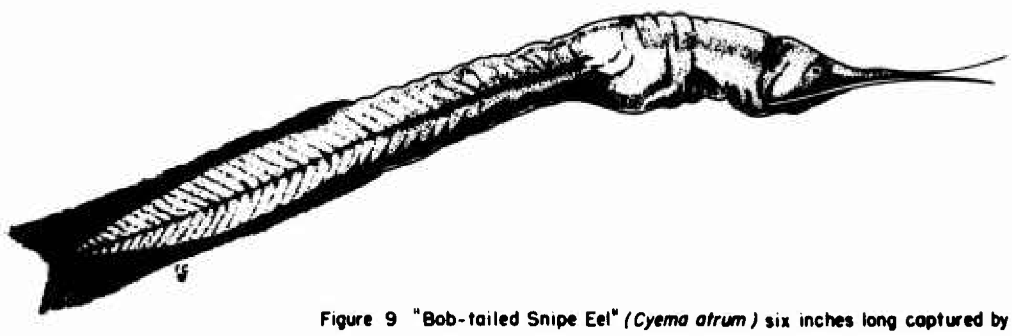


Figure 9 "Bob-tailed Snipe Eel" *(Cyema atrum)* six inches long captured by the Isaacs-Kidd Midwater Trawl at 3500 meters depth off Baja California. This fish was not known to exist in the north Pacific.

Figure 10. *Argyropelecus affinis* (one of the hatchet fish) caught at 2280 meters depth off Baja California. Eyes point upward, light organs point downward.

Figure 11. Fang-Tooth *(Caulolepis longidens)* captured by the Isaacs-Kidd Midwater Trawl at 700 meters depth in the Coronado Trough, off San Diego.

2) Individuals of species taken previously using other devices and recently captured using the IKMT have been larger in size, indicating that the larger and more powerful forms have difficulty escaping the trawl.

3) The IKMT captures large numbers of adult specimens as well as juveniles where other devices have succeeded in taking only younger specimens.

A feature of the present design of the trawl (noticed during performance tests)is that a current barrier is created across the mouth of the net by the depressing action of the vane. It is felt that once a fast-swimming fish has passed through the barrier within the net its chances of escaping are considerably reduced. It has been noticed in experiments with various liners and cod end containers that if the flow into the cod end is relatively small, a greater percentage of the water in the current barrier is filtered through the top panel of the net. The location and extent of this filtering can be roughly estimated from the quantity of specimens caught on the coarse mesh in the top panel. As the flow into the cod end is increased, however, the quantity of water filtered through the top panel diminishes to a point where it can be said that filtering in the funnel portion is evenly distributed through 360 degrees about the longitudinal axis of the net.

the net

Tests were conducted to determine an optimum net length. After several experimental configurations the present length was established as standard. The tests were largely a matter of trial and error to select a net long enough to capture specimens without "saddle-bagging" numbers of them in the mesh and yet short enough to reduce drag to a reasonable value.

A trawl with the net lined with fine mesh netting throughout its length has been tested. Although not enough hauls have been made using the fully lined net to study the quantity of catch relative to the standard liner's effectiveness, the fully lined net has demonstrated ability to take comparatively greater quantities of the smaller organisms.

the cod end container

The ultimate solution to preserving specimens in the cod end was found to be a balance between filtering through the net liner material and flow through the cod end terminus. The balance was obtained by experiment, since such factors as rate of clogging, area of cod end opening, and netting size prevent formation of an empirical rule for flow. Flow into the cod end container is exhausted so as to minimize turbulence, circulation within the container, or any other water motion which might subject the specimens to abrasion from the container material.

A standard meter net has been adapted to the trawl in place of the usual cod end can to capture the more delicate specimens. The adaptation has met with considerable preliminary success in taking specimens undamaged at speeds between 4 and 5 kt.

conclusions

In operation the IKMT has proved to be reliable and foolproof. It is very stable and is easily handled from a vessel of moderate size (using a suitable boom) in general sea conditions. It is the only device developed so far which is efficient in collecting specimens at some depth at relatively high speed (4.6 kt) using a reasonable amount of cable.

The IKMT reaches great depths using less cable, in less time than any conventional net because of its self-depressing characteristic. Conventional nets (essentially pure drag) depend upon weight of cable for their diving properties.

For these reasons the IKMT is definitely the most effective device yet used to capture the larger and more active midwater creatures. Although there are larger and faster specimens yet to be taken at midwater depths, the IKMT has already captured approximately 20 new species of fish, several representing new genera and one probably representing a new family. A considerable number of specimens have been taken that were hitherto not known to exist in the eastern Pacific.

The IKMT should prove extremely useful for investigating the scattering layer.

The trawl would be useful in any survey in which collection of midwater vertebrates and invertebrates would be of scientific or military importance.

recommendations

future tests

It is recommended that the following studies of the IKMT be conducted:

1) Calibrate the trawl using an accurate, reliable indicator for depths exceeding 2000 m.

2) Investigate flow at net entrance and filtering rate through the coarse mesh of the net vs filtering rate through the cod end liner.

3) Investigate the possibility of exhausting water through a center open section of the cod end container while filtering water at the periphery of the container at a reduced rate.

4) Investigate methods of removing specimens from the relatively high velocity stream entering the cod end container and trapping them in still water collecting areas to obtain minimum specimen damage and maximum collecting efficiency.

5) Conduct tests to determine the effects of variation of vane dihedral upon diving efficiency, with improvement of high-speed performance as the objective.

6) Investigate the effectiveness of a larger trawl in capturing the larger and faster specimens at midwater depths. It is certain that the present trawl is not taking the large, fast squid - and probably is not taking certain fish.

7) Explode small charges from a cable 100 ft or so in front of the existing trawl in an attempt to capture some of the larger creatures, which would be stunned and swept into the net.

modification of present trawl

It is recommended that the following modifications be made to the existing configuration:

1) Incorporate some sort of closing arrangement whereby collection of specimens is stopped when the trawl is being retrieved. With the present arrangement it is difficult to be certain that specimens taken are exclusively from midwater level. (A similar opening device which would prevent fish from upper levels from entering the trawl as it settles to midwater depth would be desirable but is not considered a necessity.) An alternative would be to permit selective sampling using a three-compartment cod end container for capture while descending, while at depth, and while retrieving. It is felt that by opening and closing each compartment, automatically or by messenger, many valuable specimens could be captured that would elude the trawl if the net were closed off except while at depth.

2) Investigate the possibilities of constructing the vane in a manner such that it could be folded by messenger. Retrieving the trawl from depths would be greatly simplified using such an arrangement. Depressing action would stop and the trawl could be retrieved without its diving deeper. Retrieving the trawl and stowing it aboard ship would be facilitated.

3) Enclose vane tension member in a steamlined rubber fairing. Continued use of the 10-foot trawl has indicated that there is considerable vibration in the tension member. The vibration causes fatigue failure in its elements and may frighten specimens.

4) Investigate the possibility of fabricating the depressing vanes of fiberglass laminate, reinforced with steel tubing.

scientific use

Indications are that the IKMT would be quite useful in a general faunal survey. It is expected to be extremely effective in determining whether different currents and water masses have distinct fauna. It is possible that racial differences will be found among fish from different water masses. Protracted complete coverage of the Pacific may disclose a geographic distribution of vertebrates and invertebrates and provide an index to the various water masses.

Using the meter net cod end adaptation or a modified cod end container accomplishing the same purpose, it should be possible to form an idea of the life development of a species by taking juveniles as well as adults, all in good conditions.

Specimens taken undamaged lend themselves more readily to physiological study. Especially significant in such a study of midwater specimens is the possibility of studying how these creatures have adjusted to the extremely high pressure and low oxygen tension existing at such depths.

Since so many of the midwater specimens are but poorly known it will require extensive research to make identifications and prepare descriptions.

development of other models

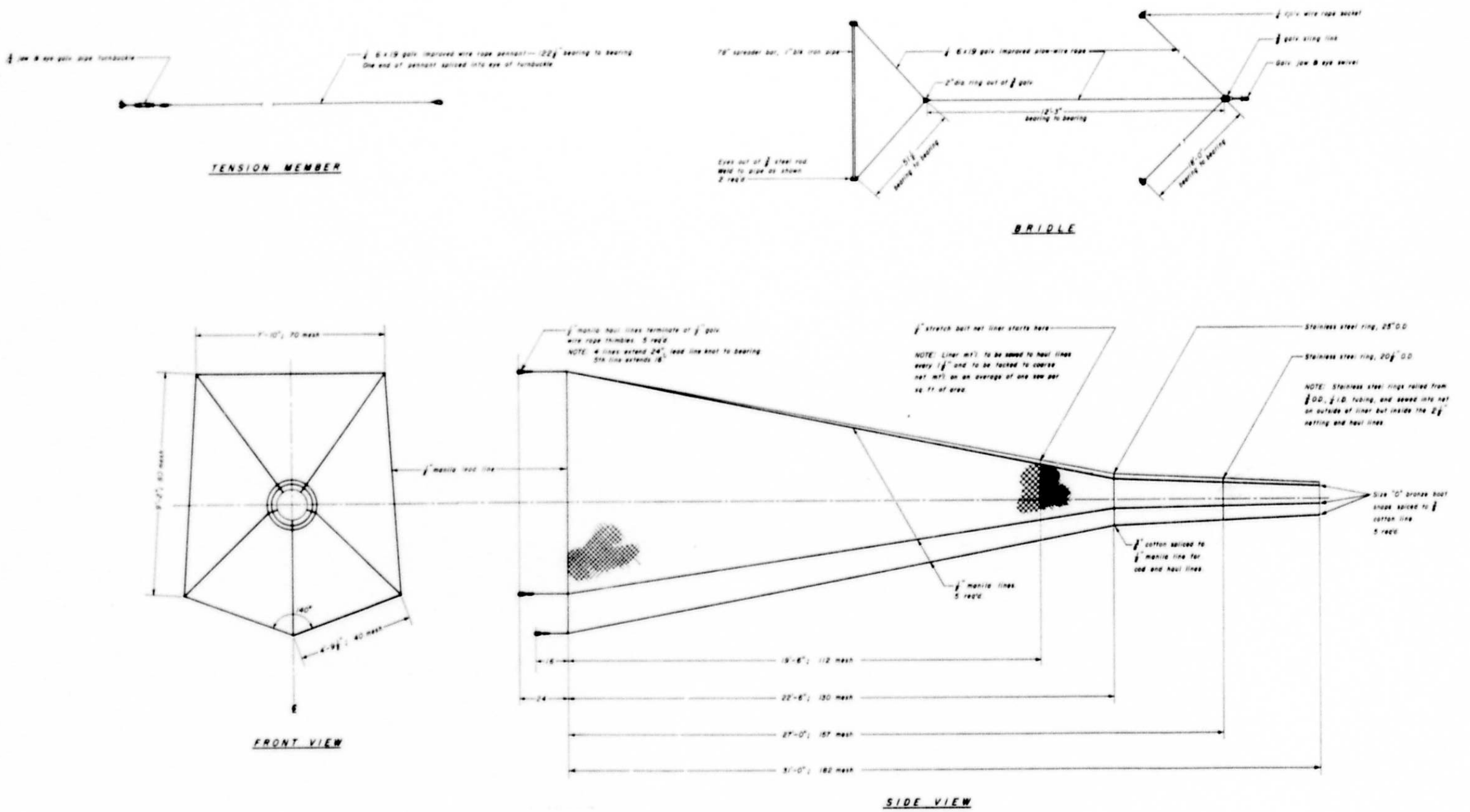
A larger, more effective trawl of similar design is looked forward to with great anticipation. It is recommended that it should be 50 ft across the net inlet and 200-to 250 ft long for use from vessels the size of Scripps Institution's R/V Horizon.

The 50-foot trawl would be towed at a somewhat slower speed than are the 10-or 15-foot trawls. Luminescence, almost certainly a problem in taking specimens in the midwater area, should be considerably reduced in towing slowly with the large trawl. The slower towing speed should also reduce noise, which all trawls or nets create.

A 5-foot trawl for use from smaller vessels should also be developed.

latent possibilities

Investigation should be made of the possibility of using the trawl (modified) for high-speed surface trawling for fast-moving, schooling fish. The modification would involve a configuration which would tow to one side and thus would not be sampling disturbed water directly astern of the towing ship. It would probably require development of a smaller trawl possessing great rigidity to withstand speed and the extreme and variable loads that would be imposed by surface waves.



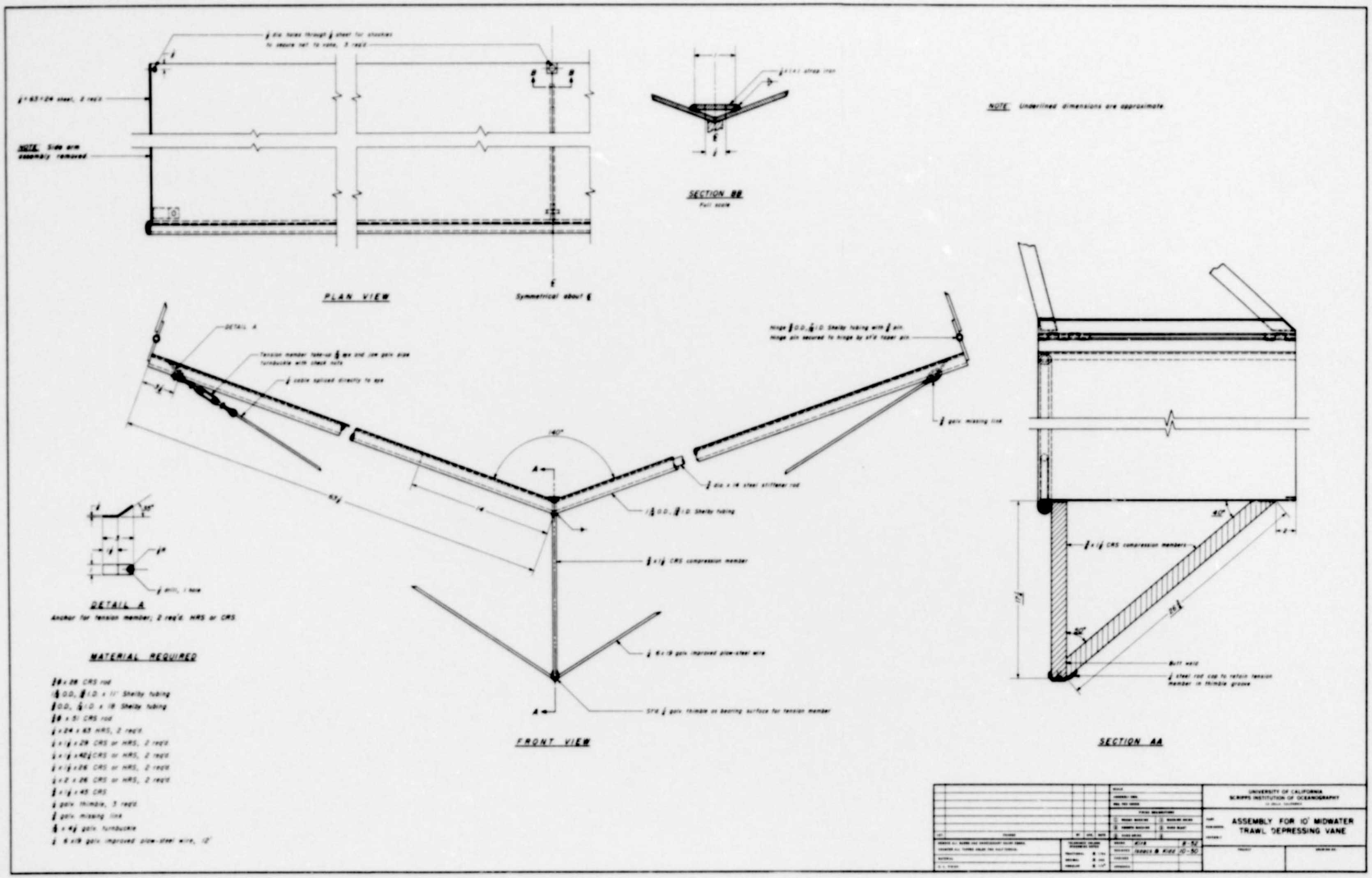
NOTE:

Mt'l: 2¼" stretch, no. 24 med lay seine netting.

Liner mt'l: ¼" stretch bait netting.

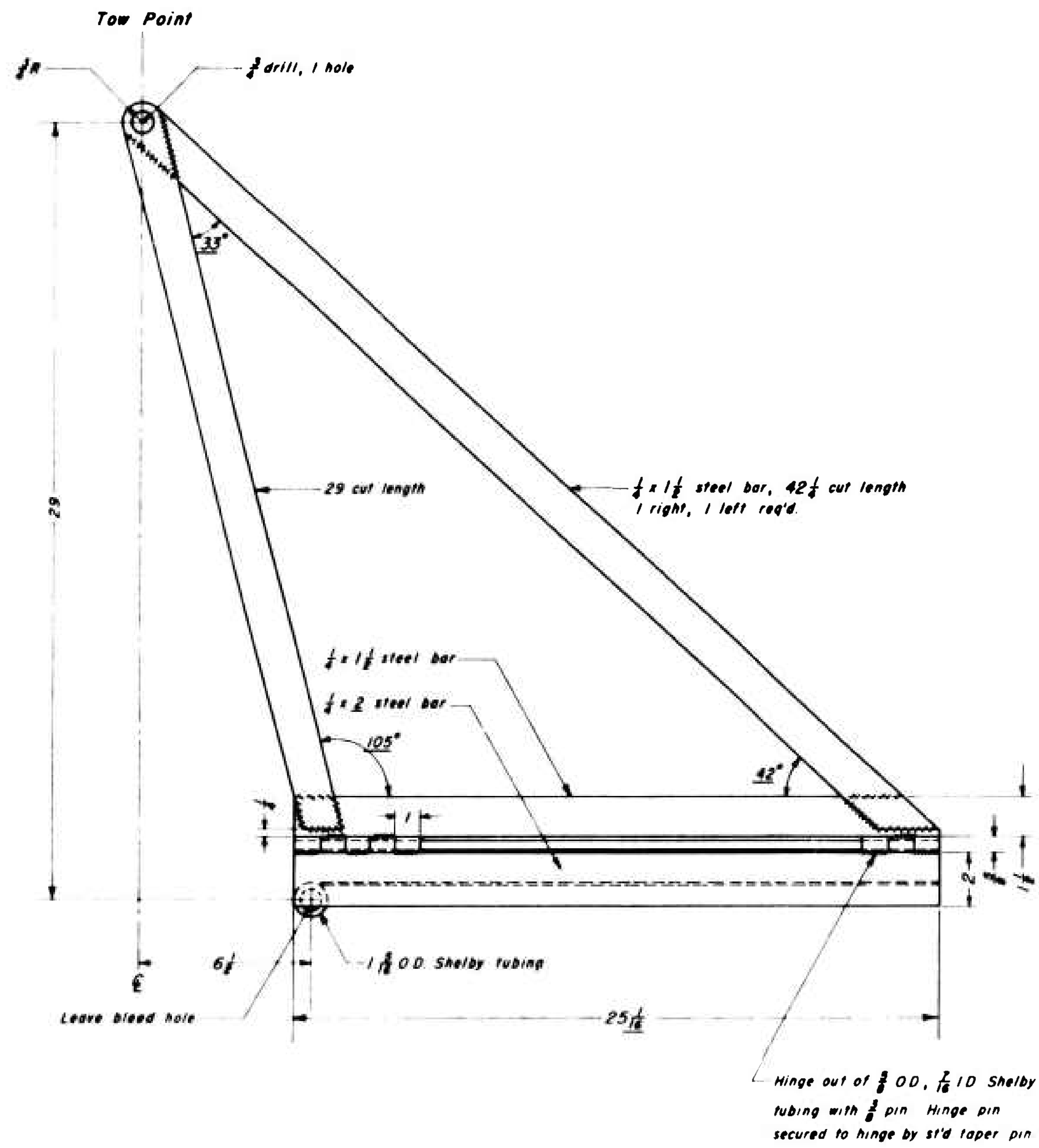
Finish: To be tanned in oat bark.

UNIVERSITY OF CALIFORNIA SCRIPPS INSTITUTION OF OCEANOGRAPHY	
10' MIDWATER TRAWL NET, BRIDLE, & TENSION MEMBER	
Drawn: Kira	8-52
Isaacs & Kidd	10-50



NOTE: Underlined dimensions are approximate
NOTE: Side arm assembly removed
PLAN VIEW
Symmetrical about ℄
SECTION BB
Full scale
DETAIL A
FRONT VIEW
SECTION AA
DETAIL A
Anchor for tension member; 2 req'd. HRS or CRS
MATERIAL REQUIRED
Shelby tubing
Shelby tubing
CRS rod
CRS or HRS, 2 req'd
galv. thimble, 3 req'd
galv. missing link
galv. turnbuckle
galv. improved plow-steel wire
Butt weld
UNIVERSITY OF CALIFORNIA
SCRIPPS INSTITUTION OF OCEANOGRAPHY
ASSEMBLY FOR 10' MIDWATER
TRAWL DEPRESSING VANE
Isaacs & Kidd
10-50

NOTE: *Underlined dimensions are approximate.*



REQ. PER ASSEM.	2
MATERIAL	Steel
DRAWN	Kirk — 8-52
DESIGNED	Isaacs & Kidd — 10-50

UNIVERSITY OF CALIFORNIA
SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

SIDE ARM FOR 10' MIDWATER DEPRESSING VANE